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COMPARATIVE ANALYSIS OF SOME SOIL CHARACTERISTICS ON BÜKK AND AGGTELEK KARST (HUNGARY) WITH SPECIAL REGARDS TO ORGANIC MATERIAL

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Summary

In the essay I study the pH, carbonate content and organic matter content of soils in karst areas. In the last ten years the investigation of soils in Hungarian karst came into limelight. The soil has an important role in the ecological system because it can buffer the harmful environmental effects that take effect quickly. I examined an 8-8 km^2 part of the Bükk Plateau and Aggtelek Karst. Both areas are protected: they are in the Bükk National Park and in the Aggtelek National Park. The soil samples were collected from areas that represent different ecological conditions: beech forest, oak forest, pine forest, beech with pine forest, beech with oak forest, seedling nursery, stubble and open field. During this investigation - among others - the pH(H_2O), the pH(KCl), the carbonate and organic matter content of 185 soil samples were measured from 48 sample sites.

Introduction

The investigation of soils that occur on karst has great importance. The soil has an important role in the ecological system of karst areas because it can buffer the harmful environmental effects that take effect quickly (*BÁRÁNY, I. – MEZŐSI, G. 1978, BÁRÁNY, I. 1980, ZÁMBÓ, L. 1986, BÁRÁNY-KEVEI, I. 1987 a, 1992*). Since the soils of karst areas are generally not used for agricultural purpose, we have only a few measured data and results.

I investigate the soil nutrient system and heavy metal content of soils in some Hungarian karst (Bükk Mountains, Aggtelek Karst, Mecsek Mountains) in different ecological conditions. For this reason we need to know the pH, carbonate content and organic matter content of the soils as well. On the one hand they are important because of the nutrient system and the mobility of heavy metals in the soils. On the other hand the pH of soils is in connection with the buffering capacity. A reduction in soil pH is often the best indication of loss of buffering capacity of a limestone soil. The acidification of soil causes an increased bedrock solution (since the acidity of the percolating water determines the solutional rates of the bedrock) and the loss of aggregate stability. These together lead to an accelerated soil loss because of the increased erosion. (*GILLIESON, D. 1988*).

I study the connection between pH, carbonate content and the limestone fragment content of soils in the different ecological conditions. The other subject of this investigation is the organic matter content of the soils: the connection between the different plant-covering, the human activity and degradation. For this reason I collected some soil samples along the same slope profiles. There are two slope profiles on Aggtelek karst (the 19-18-17.

and 20-21-22. Sample sites belong together) and three on Bükk Plateau (the 20-19-18-17., 21-22-23. and 24-25-26. Sample sites belong together).

Methods

I examine an 8-8 km^2 part of the Bükk Plateau and Aggtelek Karst (between the villages Aggtelek and Jósvafő). The soil samples come from different ecological conditions: beech forest, oak forest, pine forest, beech with pine forest, beech with oak forest, seedling nursery, stubble and open field. The soil samples are from depth of 5-10, 10-20, 20-30, 30-40 cm.

During the examination I measured the pH in distilled water and in 1 M KCl solution by digital pH-meter. I calculated the ΔpH (=$pH(H_2O)$ – pH(KCl)) of soils as well. Scheibler-calcimeter was used to determine the carbonate content of soils. The organic matter was oxidized in acid solution by $K_2Cr_2O_7$ and measured by spectrophotometer.

Discussion

The detailed description, datas and figures of the carbonate content and pH of soils are presented in my former papers (*ZSENI, A. 1999 a, b, c*). The carbonate contents are mostly below 1 %, they are often 0 %. According to this the pH of the soils is also lower than we expect it in the case of limestone bedrock.

In both areas the soils are mainly acid and weakly acid, only 1/3 part of them is neutral and weakly basic. The pH of soils mostly increases with depth. The high, often around 1 values of ΔpH indicate that in these soils the acidification tendency is important. Former measurements in dolines on Bükk Plateau and Aggtelek Karst also showed this tendency of acidification in the soils (*BÁRÁNY-KEVEI, I. 1987 b*).

The pH and carbonate content is in connection with the limestone fragment content of the soil. According to the fragment content the soils can be divided into two groups. The soils mixed with limestone fragments have higher pH, lower ΔpH values and the pH increase downwards in the soil profile to a higher degree than that in the case of soils which not mixed with limestone fragments. The latter soils have no carbonate content at all, the pH is lower and the ΔpH values are high.

There were measurements in some dolines of the Bükk Plateau (*BÁRÁNY, I. 1980, KEVEINÉ BÁRÁNY, I. 1985, 1987, BÁRÁNY-KEVEI, I. 1987 b*). The soil samples were from the different exposition of slopes and from the bottom of doline. The organic matter content of these soils varies between 2-19 %.

After my measurements I found that the organic matter content of the investigated soils is very high (*Table 1, 2, 3, 4*).

The organic matter content of soils is lower in the sample sites of Aggtelek Karst than of Bükk Plateau. The soils on Bükk Plateau retained more of its original character than on Aggtelek Karst, because the Bükk Plateau has been a protected area much longer than the other karstic region (*BÁRÁNY-KEVEI 1998*). Now the human impact is relatively small on Aggtelek Karst as well, but former the grazing, agricultural activity and forestry was common in this area. For this reason over a widespread area the soils are degraded. Nowadays the grazing is still present in this part of Aggtelek Karst. The higher degree of soil degradation since the greater importance of human activity on Aggtelek karst can cause a

lower organic matter content in the soils. This must be connected also with the quantity of precipitation (Bükk Plateau: 800 mm, Aggtelek: 650-700 mm) and the height above the sea level (Bükk Plateau: 750-830 m, in the Aggtelek area: 310-480 m). These together cause that the decomposition of organic matter is slower on Bükk Plateau.

Aggtelek Karst	organic matter content (%)			
sample site	5-10 cm	10-20 cm	20-30 cm	30-40 cm
1. (oak)	15.1	23.0	10.9	7.3
4. (oak)	12.7	8.6	9.3	5.0
8. (oak)	19.3	20.9	17.2	8.2
9. (oak)	72.6	50.0	75.2	34.1
11. (oak)	43.1	44.3	21.5	10.2
12. (oak)	29.7	16.8	18.2	10.0
13. (oak)	33.0	27.3	17.1	8.1
14. (oak)	18.0	18.7	16.2	14.9
16. (oak)	44.0	17.8	15.8	11.1
7. (pine)	15.8	13.1	12.3	5.1
3. (field)	12.6	9.4		
5. (field)	26.6	13.4	14.7	5.9
6. (field)	28.0	22.2	26.0	7.7
10. (field)	77.8	44.8	50.5	34.9
15. (field)	32.3	19.2	15.4	17.5
2. (stubble)	16.3	11.3	13.5	6.8

Table 1 The organic matter content of the soils on Aggtelek Karst

Aggtelek Karst	position	organic matter content (%)			
sample site	on the slope	5-10 cm	10-20 cm	20-30 cm	30-40 cm
19. (oak)	top	21.2	11.6	10.5	
18. (oak)	middle	16.8	11.4	14.6	9.5
17. (oak)	bottom	33.8	14.7	12.0	12.3
20. (oak)	top	26.6	18.3	16.4	
21. (mixed beech)	middle	22.4	19.3	10.2	12.2
22. (mixed beech)	bottom	24.1	12.9	10.3	12.5

Table 2 The organic matter content of the soils on Aggtelek karst, along 2 slopes

Bükk Plateau	organic matter content (%)			
sample site	5-10 cm	10-20 cm	20-30 cm	30-40 cm
2. (beech)	16.2	14.9	16.3	6.7
3. (beech)	very high	very high	very high	very high
9. (beech)	37.5	29.9	34.3	18
10. (beech)	34.9	32	20.3	15.6
15. (beech)	76.5	66.5	32.5	
5. (pine)	25.6	28.4	21.7	14.5
7. (pine)	39.6	31.3	22.6	11.8
8. (pine)	17.5	15.6	21.3	8
1. (mixed beech)	39.1	22.6	16	10.1
12. (mixed beech)	88.6	56.6	42.1	31.3
13. (seedling nursary)	55.4	49.5	39.6	24.1
4. (field)	34.9	37.1	28.6	15
6. (field)	19.6	19.5	14.3	12.2
11. (field)	55.4	37.9	46.4	12
14. (field)	29.5	22.4	20.6	13.6
16. (field)	38.2	31.7	17	7.9

Table 3 The organic matter content of the soils on Bükk Plateau

Bükk Plateau	position	organic matter content (%)			
sample site	on the slope	5-10 cm	10-20 cm	20-30 cm	30-40 cm
20. (beech)	top	very high	75.4	56.2	
19. (beech)	middle	36.6	25.9	20.7	16.1
18. (beech)	middle	36.5	28.6	36.8	
17. (beech)	bottom	38.7	31.6	17.0	18.1
21. (beech)	top	81.5	52.6	42.3	45.8
22. (beech)	middle	35.0	18.1	19.6	16.7
23. (beech)	bottom	25.9	19.7	23.1	18.7
24. (pine)	top	48.5	28.1	23.9	19.2
25. (pine)	middle	39.8	25.7	28.9	21.0
26. (pine)	bottom	66.4	46.4	31.6	15.4

Table 4 The organic matter content of the soils on Bükk Plateau, along 3 slopes

Soils of open fields

We collected soil samples on Bükk Plateau (sample sites 4., 6., 11., 14., 16.) and on Aggtelek Karst (sample sites 3., 5., 6., 10., 15.) as well. The soils of open fields on Bükk Plateau have a little bit lower pH than the soils of open fields on Aggtelek Karst. We can find acid soils on Bükk Plateau in a greater ratio (35 %) than on Aggtelek Karst (11 %). The ratio of weakly acid soils is nearly equal in both areas (55 %). The ratio of neutral and weakly basic soils is greater on Aggtelek Karst (33 %) than on Bükk Plateau (10 %). The pH of the soils on Bükk Plateau is lower both in the case of soils mixed and not mixed with limestone fragments. This must be connected with the quantity of precipitation (Bükk Plateau: 800 mm, Aggtelek: 650-700 mm) and the height above the sea level (Bükk Plateau: 750-830 m, in the Aggtelek area: 310-480 m).

The soil reaction of the stubble (Aggtelek Karst 2. sample site) is weakly basic (pH=7,6-7,9), the ΔpH values are low and the soil has more carbonate content than the soils mixed with limestone fragments in the open fields. This difference is caused by the agricultural cultivation.

The organic matter content of the soils of fields is very variable, just as in the case of forests (*Table 1 & 3*). The soils of fields on Bükk Plateau have a bit higher organic matter content than the soils of fields on Aggtelek Karst. This is in connection with the height above sea level, the precipitation and the human activity, as I have mentioned it before. In the investigated part of Aggtelek Karst the grasing is still present on the fields (in the 5., 6., 15. sample sites it is surely present), so here the supply of dead plants may be smaller. There is only one part on Bükk Plateau where grazing is allowed: on the Nagymezõ ("Great Field") where the famous stud lives. The 16. sample site takes place on this field. The lower part of this soil has less organic matter content than the soils of fields in general have in this depth. The soil of stubble (Aggtelek Karst 2. sample sites) has low organic matter content compared to the fields since the reduced supply caused by harvesting. The samples were collected from flat areas (16. (Bükk) and 2., 5., 15. (Aggtelek)), from the edge of dolines (4., 6. (Bükk) and 6. (Aggtelek)) and from gentle slopes (3., 10. (Aggtelek)). One sample site (11. Bükk) was on the bottom of a doline.

Soils of beech forests

We collected soil samples in beech forests only on Bükk Plateau (subject to the plant conditions). The weakly acid (31 %) and acid soils (24 %) dominate. There is no strongly acid soil. Neutral and weakly basic the 45 % of the soils.

The soils in beech forests are mixed with limestone fragments and according to this they have some carbonate content (usually below 1 %). The reaction of soils is neutral in the deeper layers. Closer to the surface the pH is lower. The ΔpH values are commonly not too high. There are two exceptions in the soils: in the 17. sample site the soil has no limestone fragments, so the soil reaction is lower, the ΔpH values are high and there is no carbonate content in the soil. There is a high amount of fragments in the 2. sample site, still the carbonate content is 0 %, the pH is acid (pH=4,6-5,5), and the ΔpH values are high.

The organic matter contents of the soils in beech forests are very high. In the upper layer they are usually above 30 %. But in the 30-40 cm soil layer the organic matter content is still high (*Table 3 & 4.*). The sample sites are on the bottom of slopes (2., 3., 9., 17., 23.), on the middle part of slopes (10.,15., 18., 19., 22.) and on the top of slopes (20., 21.). The 20-19-18-17. samples were collected on the same slope profile. Similarly, the 21-22-23. samples aim at comparing the characteristics of the soil along one slope. The comparison of these latter samples does not show the expected results, namely, that the soil of the bottom part of the slope has lower organic matter content because of the soil degradation. Moreover, in this case the opposite is true. This slope undulates gently, the angle of slope is only 4-5°. According to the results the erosion must be minimal. The 20-19-18-17. sample sites are on a steeper slope (the angle of slope is 9-10°). The highest – extreme high - organic matter content was measured on the top of this slope. (Here the soil is a very loose black rendzina.) There is no considerable change in the organic matter content along this slope – except the mentioned soil on the top.

Soils of oak forests

According to the plant conditions we collected soil samples in oak forests only on Aggtelek Karst. Almost the half of the examined soils are strongly acid and acid. 22 % of the soils are weakly acid, neutral and weakly basic are 32 %. We can establish that the soils in oak forests on Aggtelek Karst have lower soil reaction than the soils in beech forests on Bükk Plateau. This difference may be caused – besides by the difference in the plant-cover - by the difference in the mixing of limestone fragments. There are only 5 sample sites on Aggtelek Karst where the limestone fragments appear in the soil and in 8 sample sites the soil is not mixed with limestone fragments. But there is only 1 sample site on Bükk Plateau where the soil is not mixed with limestone fragments and in the other 12 sample sites the limestone fragments appear in the soil. (The soils on Bükk Plateau are generally thinner than the soils on Aggtelek Karst.)

The organic matter content in the soils of oak forests is lower than in the soils of beech forests, mixed beech and pine forests (*Table 1 & 2.*). There are only 5 samples of the 13 where the organic matter content of the 5-10 cm layer is above 30 %. The lower values are valid in the case of the lower layer of the soils as well.

The sample sites are on a flat area (1.), on the bottom of slopes (4., 17.), on the middle part of slopes (11., 12., 16., 18.), on the top of slopes (9., 13., 19., 20.) and in dolines (8., 14.). The 19-18-17. samples are along the same slope. The angle of slope is 9-10°. The organic matter content of soil is enriched on the bottom of the slope. This can be a proof of the redeposition of soil by erosion. The samples collected on the bottom of dolines show no enrichment of organic matter compared to the other soils in oak forests.

Soils of pine forests

I examined six soils from pine forests on the Bükk Plateau (samples 5., 7., 8., 24., 25., 26) and one (sample site 7.) on Aggtelek Karst. The pH of the soil in the pine forest on Aggtelek Karst is lower (pH= 5,0-5,3) than in the pine forests on Bükk Plateau. The pH does not increase significantly downwards in the soil profile while in the case of the pine forests Bükk Plateau the increase of the pH can be 2 units. In this soils the weakly acid (46 %) and acid (21 %) reactions dominate, but there are neutral (8 %) and weakly basic (25 %) soils as well. The limestone fragments appear in some sample sites (5., 24., 25., 26.).

The pH of soil in the seedling nursery (Bükk, 13. sample site) is weakly acid and neutral (pH=6-7), the ΔpH values are low (ΔpH=0,6-0,5). This must be connected with the chemical fertilization in this place and the high fragment content of the soil.

Just as the pH, the organic matter content of the soil in the pine forest on Aggtelek Karst is lower than in the pine forests of Bükk Plateau (*Table 1, 3 &4*). The samples were collected on the bottom of slopes (5., 7., 7. (Aggtelek), 26.), on the middle part of slope (25.) and on the top of slope (24.). The 8. sample came from the bottom of a doline. The 24-25-26. samples are along the same slope. The angle of slope is 15-16°. The enrichment of organic matter is observable on the bottom of the slope. It is interesting that the soil in the bottom of a doline has the lowest organic matter content – but still rather high – compare to the other soils in pine forest. In the seedling nursery the soil was collected on the edge of a doline. The organic matter content is high in the lower layer of soil as well. The lowest organic matter

content in the soils of pine forests was measured in the soil of the pine forest on Aggtelek Karst.

Soils of mixed beech forests

The 1. and 12. sample sites on Bükk Plateau are in beech mixed with pine forest, while the 21. and 22. sample sites on Aggtelek Karst are in beech mixed with oak and hornbeam. There is no limestone fragment in the soils on Aggtelek Karst. In the case of the mixed beech on Bükk Plateau the limestone fragments appear in the soils. In spite of this, the soils of the mixed forests on Aggtelek Karst have higher pH (88 % weakly acid and 12 % acid) than on Bükk Plateau (25 % strongly acid, 38 % acid, 25 % weakly acid and 12 % neutral). This may be caused by the difference in the plants (oak and hornbeam against pine) and the higher quantity of precipitation on the Bükk Plateau.

The sample sites are on a flat surface (1. Bükk), on the bottom of a slope (22. Aggtelek) and on the middle part of a slope (21. Aggtelek and 12. Bükk). The 21-22. sample sites are along the same slope. On the top of this slope the sample was collected in an oak forest (22. Aggtelek). The angle of slope is 15-16°. The redeposition of soil is not proved by considering the organic matter content of the soils. Although the organic matter content on the bottom of the slope is a little bit higher than on the middle part of the slope (*Table 2*)

Conclusion

In my essay I studied the soil reaction, carbonate and organic matter content of different plant-covered areas in the karstic region of Bükk Plateau and Aggtelek Karst. Although the characteristics of the bedrock point towards the fact that these soils have high carbonate content and neutral soil reaction, this is not completely justifiable. The carbonate contents are mostly below 1%. The soil reaction is dominantly acid and weakly acid, only 1/3 part of them is neutral and weakly basic. The often high, around 1 values of ΔpH warn us of the acidification tendency of these soils.

The pH and carbonate content is in connection with the limestone fragment content of the soil. The soils mixed with limestone fragments have higher pH, lower ΔpH values and the pH increase downwards in the soil profile to a higher degree than that in the case of soils which not mixed with limestone fragments. The latter soils have no carbonate content at all.

The soils of beech forests on Bükk Plateau averagely have higher pH values than the soils of oak forests on Aggtelek Karst. This is caused not only by the difference of plant covering but by the difference of fragments supply as well. The soils of fields on Bükk Plateau are more acid than the soils of fields on Aggtelek Karst. This can be mainly because the Bükk Plateau is higher above sea level and has more precipitation than the Aggtelek Karst.

The organic matter content of these soils is very high. There is no direct connection between pH and organic matter content. The redeposition of soil on the slopes is not proved on the basis of the change of organic matter content of the soils. There were only 2 of the investigated 5 slope profiles where the results show the enrichment of organic matter on the bottom of slopes. The soils of open fields have the lowest organic matter content. Of the forests the beech forests have the highest organic matter content in the soil. In general the

soils of Bükk Plateau have higher organic matter content than the soils of Aggtelek Karst. This can be because the higher amount of precipitation and the cooler weather hinder the decomposition of organic matter. The other reason is that the human impact has been stronger on the Aggtelek area so the degradation of soils is stronger.

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